University of Groningen

Development of the Endoscopic Endonasal Sinus and Skull Base Surgery Questionnaire

Ten Dam, Ellen; Feijen, Robert A; van den Berge, Minke J C; Hoving, Eelco W; Kuijlen, Jos M; van der Laan, Bernard F A M; Vermeulen, Karin M; Krabbe, Paul F M; Korsten-Meijer, Astrid G W

Published in:
International forum of allergy & rhinology

DOI:
10.1002/alr.22000

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2017

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):
Ten Dam, E., Feijen, R. A., van den Berge, M. J. C., Hoving, E. W., Kuijlen, J. M., van der Laan, B. F. A. M., Vermeulen, K. M., Krabbe, P. F. M., & Korsten-Meijer, A. G. W. (2017). Development of the Endoscopic Endonasal Sinus and Skull Base Surgery Questionnaire. *International forum of allergy & rhinology*, *7*(11), 1076-1084. https://doi.org/10.1002/alr.22000

Copyright
Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment.

Take-down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): http://www.rug.nl/research/portal. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

Development of the Endoscopic Endonasal Sinus and Skull Base Surgery Questionnaire

Ellen ten Dam, MD[1,2], Robert A. Feijen, MD, PhD[1], Minke J.C. van den Berge, MD[1], Eelco W. Hoving, MD, PhD[3], Jos M. Kuijlen, MD, PhD[3], Bernard F.A.M. van der Laan, MD, PhD[1], Karin M. Vermeulen, MD[4], Paul F.M. Krabbe, MD, PhD[4] and Astrid G.W. Korsten-Meijer, MD, PhD[1]

Background: **The patients' perspective of health outcomes has become important input for assessing treatment effects. However, existing endoscopic endonasal surgery (EES) instruments are not fully aligned with the concept of health-related quality of life (HRQoL). A prospective cohort study was therefore conducted to develop a suitable quality-of-life tool to assess nasal morbidity after EES: the Endoscopic Endonasal Sinus and Skull Base Surgery Questionnaire (EES-Q).**

Methods: **The study included 300 patients: 207 with sinus pathology and 93 with anterior skull base pathology. The EES-Q was administered prior to surgery and postoperatively (2 weeks, 3 months, and 1 year). Psychometric instrument properties were tested and relevant health domains were formulated. Seventy-two items were generated by the conventional psychometric approach. An exploratory factor analysis was used to test construct validity. The optimal number of factors to retain was determined by using the eigenvalues-greater-than-1 rule and scree plot. Orthogonal varimax rotation was used to enhance interpretability. Internal consistency was assessed using the Cronbach α.**

Results: **The factor analysis yielded a 3-factor solution, representing physical, psychological, and social functioning. The final version of the instrument consisted of 30 items with a high internal consistency (>0.80) for all 3 HRQoL domains.**

Conclusions: **The EES-Q is a comprehensive, multidimensional, disease-specific instrument. A distinguishing characteristic is that, apart from the physical and psychological domains, the EES-Q also encompasses a social domain. Understanding different HRQoL aspects in patients undergoing EES may help caregivers restore, improve, or preserve the patient's health through individualized care, which depends on identifying their specific needs.** © 2017 ARS-AAOA, LLC.

Key Words:
anterior skull base; chronic rhinosinusitis; endoscopic sinus surgery; endoscopic skull base surgery; paranasal sinus diseases; patient-reported outcome measure; quality of life

***How to Cite this Article*:**
ten Dam E, Feijen RA, van den Berge MJC, et al. Development of the Endoscopic Endonasal Sinus and Skull Base Surgery Questionnaire. *Int Forum Allergy Rhinol.* 2017;xx:1-9.

[1]*Department of Otorhinolaryngology–Head and Neck Surgery, University Medical Center Groningen, University of Groningen, Groningen, The Netherlands;* [2]*Graduate School of Medical Sciences Institute for Drug Exploration, University of Groningen, Groningen, The Netherlands;* [3]*Department of Neurosurgery, University Medical Center Groningen, University of Groningen, Groningen, The Netherlands;* [4]*Department of Epidemiology, University Medical Center Groningen, University of Groningen, Groningen, The Netherlands*

Correspondence to: Ellen ten Dam, MD, Department of Otorhinolaryngology–Head and Neck Surgery, University Medical Center Groningen, University of Groningen, Hanzeplein 1, 9700 RB Groningen, The Netherlands; e-mail: e.ten.dam@umcg.nl

Potential conflicts of interest: None provided.

Received: 22 May 2017; Revised: 17 July 2017; Accepted: 25 July 2017
DOI: 10.1002/alr.22000
View this article online at wileyonlinelibrary.com.

Traditionally, clinicians have used objective endpoints to assess a given treatment effect, but, over time, they have recognized the importance of taking the patient's perspective into account.[1,2] Essentially, treatment envisions the restoration, improvement, or preservation of health, and the extent to which the patient's overall well-being is affected by a medical condition or treatment can be measured in terms of health-related quality of life (HRQoL).[3] HRQoL is generally described in 3 domains: physical, psychological and social functioning.[2,4]

The therapy of choice to approach pathology of the paranasal sinuses and/or anterior skull base is endoscopic endonasal surgery (EES). Its primary cause of morbidity is nasal trauma.[5,6] For instance, nasal discharge,

blockage and altered sense of smell are common patient-reported postoperative complaints. Although altered postoperative nasal function is a transient factor, it does affect HRQoL.[2,7–9] In this light, the transsphenoidal approach in patients with anterior skull base pathology warrants extra attention because these patients usually have a normal-functioning nasal mucosa before the procedure.

Given the promising developments in EES, in combination with the growing recognition of the patients' perspective, it is essential to use an HRQoL instrument in decisions on the most appropriate surgical treatments. However, the existing EES instruments are not fully aligned with the HRQoL concept. Each of the available instruments has its specific limitations.[1,2,10] For instance, some are unidimensional or do not specifically assess nasal morbidity.[6,11,12] Others were devised for the context of skull base tumors[13] or chronic rhinosinusitis,[14] or for patients with malignant pathology.[11]

Our aim was to develop a disease-specific HRQoL instrument for patients undergoing EES for sinus or skull base pathology to assess nasal morbidity after treatment. This instrument is intended to cover 3 domains: physical, psychological and social functioning. The instrument will be applicable for sinus as well as anterior skull base pathology.[2,4] During development, the psychometric properties of the instrument would be tested.

Materials and methods

Application of the HRQoL concept

HRQoL is generally described in a physical, psychological and social domain. For patients undergoing EES, subdomains were specified within each of the 3 general HRQoL domains: nasal, visual, and neurologic complaints; psychological distress; and functional status and social interactions, respectively.[2,4,9,15] Specific criteria that the EES-Q should meet were identified: (1) items should be formulated in a similar way; (2) the response format should be uniform; (3) items should be suitable for constructing Likert scales; and (4) the instrument should contain 10 items per domain. Overall, the self-report instrument should be understandable to the patient.[15] Each item was formulated as a complaint or activity with a 5-point Likert response scale to indicate the degree the complaints or activities have bothered the respondent over the past 2 weeks. The response scale was presented as follows: 1 = not at all; 2 = mildly; 3 = moderately; 4 = severely; and 5 = very severely.

Selection of items

The conventional psychometric approach was followed.[15] The first critical task in the development of the EES-Q was to select health items that best represent overall HRQoL for patients undergoing EES. To identify relevant items, both generic and disease-specific HRQoL instruments were used: the 22-item Sino-Nasal Outcome Test (SNOT-22)[14]; the Skull Base Inventory (SBI)[13]; the 12-item Anterior Skull Base Nasal Inventory (ASK Nasal-12)[6]; the Anterior Skull Base QoL Questionnaire (ASBQ)[11]; the Center for Epidemiological Studies Depression Scale (CES-D)[16]; the Beck Depression Inventory (BDI)[17]; the 36-item Short Form Health Survey Questionnaire (SF-36); and the Assessment of Quality of Life (AQoL) 8D.[18] Other sources used were expert opinions of 2 otorhinolaryngologists and 2 neurosurgeons from the University Medical Center Groningen (UMCG) and a total of 10 patient interviews. A pilot version of the instrument was administered to 10 patients who had already had EES, and the results led to adjustments.

Study population

From August 2013 until May 2015, 324 patients underwent EES at the Department of Otorhinolaryngology–Head and Neck Surgery of the UMCG. Whereas most patients were treated by an otorhinolaryngologist, patients with anterior skull base pathology were treated by a multidisciplinary team consisting of an otorhinolaryngologist and a neurosurgeon, who performed endoscopic transsphenoidal surgery. Three criteria were applied for inclusion in our study, with all patients: (1) treated by EES; (2) able to read and write Dutch; and (3) ≥18 years of age. Twenty-four patients were excluded for various reasons, including: lack of data (n = 13); an impaired mental state (n = 1); the operation involved only septal/turbinate surgery (n = 4); or an external approach was performed in addition to the endoscopic approach (n = 3). Three patients with suspected cerebrospinal fluid (CSF) leakage exhibited no such leakage during EES and therefore no anterior skull base reconstruction was performed.

Study design

Formal approval for the study was obtained from the local institutional review board of the UMCG before commencing. The day before surgery, eligible patients were informed about the study and asked to participate. Written informed consent was obtained and patients completed the preoperative questionnaire. The instrument was administered again at the outpatient clinic 2 weeks postoperatively. Assuming that HRQoL at 2 weeks postoperatively would provide a salient baseline, this time-frame was set for the psychometric analysis. For the long-term evolution of HRQoL, the patients were also asked to complete the instrument at 3 months and again 1 year postoperatively. To generate data for a planned validity study (not shown), 2 other instruments were administered 3 months postoperatively to a cohort of 100 patients within the study population.

Statistical analysis

An exploratory factor analysis (by maximum-likelihood extraction) was used to test construct validity. The correlation matrix that formed the basis for a factor analysis was tested with different assumptions. Items with repeated low (<0.40) or high (>0.90) correlations were excluded. The Kaiser-Meyer-Olkin (KMO) measure verified the sampling

adequacy for the analysis; a minimum of 0.50 was required. Bartlett's test of sphericity was used to test the hypothesis that the correlation matrix is an identity matrix (that is, all diagonal elements are 1 and all off-diagonal elements are 0, implying that all of the variables are uncorrelated). Missing individual items were deleted pairwise. Eigenvalues for each factor were obtained. Then, based on a scree plot and the eigenvalues-greater-than-1 rule, the number of extracted factors was determined. An orthogonal varimax rotation was used to enhance the interpretation of the factor structure, whereby a factor loading of >0.50 for an item was considered noteworthy. After determining the set of candidate items for each domain by factor analysis, the internal consistency of the domains was assessed with Cronbach's α (>0.70 was considered sufficient). The results were visualized with biplots, exploratory graphs that simultaneously display patients (rows), and the relative positions of the items (variables).[19] $p < 0.05$ was considered statistically significant. IBM SPSS Statistics version 22.0 (SPSS IBM, Inc., Armonk, NY, USA) was used for calculations.

Results

Patients' characteristics

Three hundred patients were included in this study: 1 group (69.0%) consisted of patients with pathology of the paranasal sinuses and the other group (31.0%) consisted of patients with anterior skull base pathology. In the latter group, pituitary adenomas were the most commonly observed type (Table 1).

There were 207 (69%) patients with pathology of the paranasal sinuses (Table 1). Of these 207 patients, 125 (60.4%) had undergone prior EES. Intraoperatively, an anterior skull base defect was encountered in 4 (1.9%) patients, which complicated the procedure. These 4 patients underwent extended EES to debulk a tumor located in the frontal recess or to open the frontal recess. Postoperatively, 1 of these 4 patients had relapsing CSF leakage. Chronic rhinosinusitis was diagnosed in 165 (79.9%) of the 207 patients. Diseases associated with chronic rhinosinusitis were allergic rhinitis (35.8%), asthma (20.6%), cystic fibrosis (2.4%), granulomatous vasculitis (1.8%), Samter's triad (3.0%) and immune deficiency (1.2%).

The other group consisted of 93 (31.0%) patients with anterior skull base pathology (Table 1). Of these 93 patients, 22 (23.7%) had undergone prior EES. Multilayer reconstruction of minor skull base defects was performed with hemostatic agents (Surgicel) and/or fibrin sealant path (Tachosil) in combination with fibrin glue (Tissuecol). Multilayer reconstruction of expected larger defects of the diaphragm was performed in 5 (5.4%) patients, with grafts obtained from fascia lata, mucosa of a nasal turbinate, or cartilage in combination with tissue sealant. The nasoseptal flap[20] was used in 5 (5.4%) patients. Additional external lumbar drainage (ELD) was placed postoperatively in 4 of these 10 patients for 3–5 days. Postoperatively, 10

TABLE 1. Patients' characteristics

Characteristic	Pathology [n (%)]	
	Anterior skull base (n = 93)	Paranasal sinuses (n = 207)
Gender		
Male	46 (49.5)	108 (52.2)
Female	47 (50.5)	99 (47.8)
Mean (SD) age (in years)	55.6 (12.8)	50.0 (14.0)
ASA		
I	19 (20.4)	56 (27.1)
II	57 (61.3)	118 (57.0)
III	16 (17.2)	32 (15.5)
IV	1 (1.1)	1 (0.5)
History of EES	22 (23.7)	125 (60.4)
Diagnosis		
Pituitary adenoma	78 (83.9)	NA
Skull base defect[a]	5 (5.4)	NA
Cholesterol granuloma	2 (2.2)	NA
Other[b]	8 (8.7)	NA
Chronic rhinosinusitis	NA	165 (79.7)
Mucocele	NA	17 (8.2)
Inverted papilloma	NA	15 (7.2)
Other[c]	NA	10 (4.9)
Type of surgery		
Transsphenoidal approach	93 (100)	NA
Limited FESS[d]	NA	56 (33.9)
Extended FESS[d]	NA	102 (61.8)
Medial maxillectomy II-III	NA	7 (4.2)
Complications		
CSF leakage	10 (10.8)	1 (0.5)
Nosebleed	4 (4.3)	4 (1.9)
Urinary tract infection	2 (2.2)	NA
Conjunctivitis	NA	2 (1.0)
Other[e]	NA	3 (1.4)
Reoperation	8 (8.6)	1 (0.5)

[a]Causes of the skull base defects were iatrogenic, posttraumatic, or spontaneous.
[b]Includes meningioma, haemangioma, myxoid chondrosarcoma, posttransplant lymphoproliferative disorder, multiple myeloma, ectopic pituitary adenoma, undifferentiated squamous cell carcinoma, and craniopharyngioma.
[c]Includes juvenile angiofibroma, schwannoma maxillary nerve, planocellular carcinoma, low-grade adenocarcinoma, melanoma, and osteoma.
[d]FESS was divided into limited (infundibulotomy, ethmoidectomy, Draf I) and extended (sphenoidectomy, Draf II, Draf III).
[e]Includes nasolacrimal duct injury, burn nasal vestibule, and bradycardia during surgery. ASA = American Society of Anesthesiologists; CSF = cerebrospinal fluid; EES= endoscopic endonasal surgery; FESS = functional endoscopic sinus surgery; NA = not applicable; SD = standard deviation.

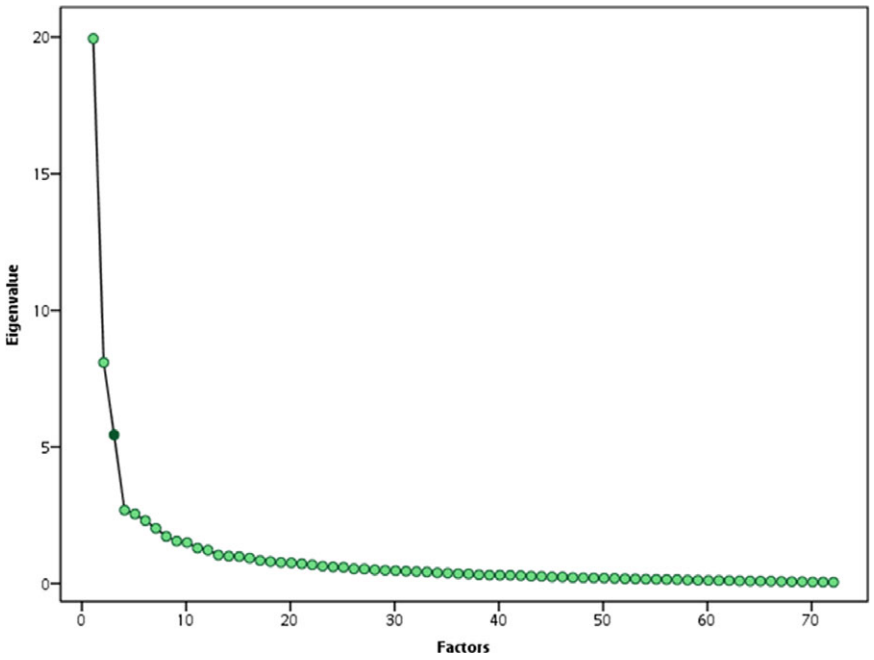

FIGURE 1. Scree plot. The plot shows the percentage of explained variance (eigenvalues) for the factors. The inflexion point of the curve is at 4 factors, suggesting that a 3-factor solution is appropriate (dark dot).

(10.8%) patients had CSF leakage and in 1 of these patients this leakage was associated with meningitis. A postoperative nosebleed was seen in 4 (4.3%) patients and 2 (2.2%) patients had a urinary tract infection. Reexploration was necessary in 8 (8.6%) patients because of CSF leakage (n = 6) or a nosebleed (n = 2). A pituitary adenoma was present in 78 (83.9%) patients: 59 (75.6%) were macroadenomas and 19 (24.4%) were microadenomas. Endocrine hypersecretion was present in 29 (37.2%) patients. Cavernous sinus invasion and suprasellar extension was present in 35 (44.9%) and 52 (66.7%) patients, respectively.

Factor analysis

The KMO measure of sampling adequacy was 0.90. Bartlett's test of sphericity was significant (χ^2 [17,964] = 2556, $p < 0.001$). In the diagonal of the anti-image correlation matrix, no values <0.50 were observed. Based on the eigenvalues-greater-than-1 rule, 14 factors were extracted, together explaining 65.9% of the total variance. The scree plot showed an inflexion point at 4 factors, indicating that a 3-factor solution was appropriate (Figure 1). The 3-factor solution explained 44.4% of the variance. The varimax-rotated factor solution showed 3 factors with the associated items (Table 2). Twenty-one items showed no significant factor loading (<0.50) and were eliminated (Table 2). It was shown that the items concerning sleep, initially hypothesized to belong to the psychological domain, appeared to load more strongly onto the physical domain.

Internal consistency

Physical domain

Cronbach's α of the physical domain with 16 items was 0.92. An increased Cronbach's α was not observed after removing any of the 16 items. To create a domain containing 10 items with the highest possible overall Cronbach's α, the items with the lowest inter-item correlation were removed, including "runny nose", "coughing" and "shortness of breath". To retain sinonasal-related items, it was decided to remove some sleep-related items. The items "exhausted", "slow start to the day", "sleepiness through the day" and "interrupted sleep" had the lowest inter-item correlation and were therefore removed. Based on the exploratory factor analysis of the preoperative data and the expert opinion of the otorhinolaryngologists, it was decided to add "reduced sense of smell" to the physical domain, despite a modest factor loading of 0.41 (ie, clinimetric consideration). Two weeks postoperatively, some degree of reduced smell was present in 189 (63.0%) of the patients. Besides "reduced sense of smell," the item "nasal crusting" had no significant factor loading (<0.50). Surgeons observe some degree of nasal crusting while performing sinonasal endoscopy.[7] As the concept of our HRQoL instrument is focused on experienced level of complaints, we were less interested in factual conditions such as "nasal crusting" but far more in the outcome of this condition.[21] Instead of complaining about nasal crusting itself, patients complain more often about a blocked nose or facial pressure. The factor loadings of "blocked nose" and "facial pressure" were 0.61 and 0.63, respectively, and these items were included in the EES-Q. The final Cronbach's α was 0.87.

TABLE 2. Rotated factor solution

Item	Factor		
	1	2	3
1. Crusts in nose			
2. Nosebleed			
3. Postnasal drip			
4. Green discharge (when blowing nose)			
5. Thick discharge (when blowing nose)			
6. Smelly discharge (when blowing nose)			
7. Bad odor in nose			
8. Blocked nose		0.61	
9. Runny nose		0.53	
10. Reduced sense of smell			
11. Absent sense of smell			
12. Reduced sense of taste		0.54	
13. Absent sense of taste			
14. Need to blow nose		0.55	
15. Coughing		0.52	
16. Difficulty breathing through nose		0.60	
17. Shortness of breath		0.51	
18. Dry mouth		0.67	
19. Headache			
20. Facial pressure		0.63	
21. Blurry vision			
22. Eyesight not sharp			
23. Seeing double			
24. Loss of part of the field of vision			
25. Tearing / irritated eyes			
26. Numbness / reduced sensation in cheek			
27. Numbness / reduced sensation in teeth			
28. Numbness / reduced sensation in roof of mouth			
29. Feeling depressed	0.78		
30. Sad	0.87		
31. Feeling down	0.87		
32. Distressed	0.82		
33. Unhappy	0.76		
34. Less appetite			
35. Impatient / restless	0.53		
36. Aggravated	0.67		
37. Frustrated	0.71		
38. Stressed	0.72		
39. Irritable / annoyed	0.70		
40. Tense	0.68		
41. Worried	0.63		
42. Nervous	0.58		
43. Afraid / anxious	0.63		
44. Despondent	0.67		
45. Reduced self-confidence	0.72		
46. Low self-esteem	0.68		
47. Fitful sleep		0.64	
48. Slow start to the day		0.53	
49. Exhausted		0.55	
50. Tired		0.63	
51. Wake up tired		0.68	
52. Interrupted sleep		0.64	
53. Sleepiness during the day		0.58	
54. Angry	0.68		
55. Feeling excluded	0.65		
56. Discouraged	0.76		
57. Embarrassed	0.58		
58. Work / study			0.72
59. Taking part in traffic			0.77
60. Leisure time activities			0.86
61. Hobbies			0.84
62. Indoor activities at home			0.83
63. Outdoor activities at home			0.87
64. Family role and household chores			0.74
65. Going out for a visit			0.84
66. Shopping			0.84
67. Dining out			0.75
68. Stepping out (pub or party)			0.74
69. Grooming (ie, bathing, dressing)			
70. Daily activities			0.77
71. Engaging in outdoor activities			0.88
72. Physical exertion			0.82

(Continued)

Variables with a loading of <0.05 are suppressed.

Psychological domain

For the psychological domain with 21 items, the Cronbach's α was 0.96. Removal of any of the 21 items did not lead to an increase in Cronbach's α. To create a domain consisting of 10 items with the highest possible overall Cronbach's α, items with the lowest inter-item correlation were removed, including "embarrassed", "feeling excluded", "desperate", "low self-esteem", "afraid/anxious", "reduced self-confidence", "angry", "unhappy", "nervous", "impatient/restless" and "irritable/annoyed". The final Cronbach's α was 0.94.

Social domain

The social domain with 14 items had a Cronbach's α of 0.97. Removal of any of the 14 items did not lead to an increase in Cronbach's α. "Work/study" showed the lowest inter-item correlation and was thus removed. However, some degree of discomfort when performing work or study was reported by 185 (62%) patients 2 weeks postoperatively. Therefore, it was decided to reinstate that item. To create a social domain with 10 items, the following items were subsequently removed in consecutive order: "family role and household chores", "taking part in traffic", "stepping out (pub or party)" and "dining out". The highest final Cronbach's α was 0.96. The final version of the EES-Q consisted of 30 items (Fig. 2).

Biplots

The biplots generated for the 3 domains of HRQoL are shown in Figure 3. The impact of the items was the same for both diagnostic groups. Also identical was the degree to which a complaint was present after EES.

Discussion

The goal of this study was to develop a multidimensional, disease-specific HRQoL instrument for patients undergoing EES to assess nasal morbidity after treatment. A distinctive characteristic of the EES-Q, developed under the HRQoL framework, is that it is a comprehensive instrument encompassing apart from a physical and psychological domain also a social domain. In addition, psychometric properties of the EES-Q were tested. The internal consistencies of the health domains it covers are excellent. The EES-Q seems to be a promising instrument to evaluate HRQoL after EES.

To date, the literature has not described any instrument to evaluate HRQoL after EES that encompasses the 3 key domains of HRQoL: physical, psychological and social functioning.[2,4] The impact of EES on HRQoL is often studied using the ASBQ.[11] The ASBQ is a multidimensional, disease-specific instrument validated for use in open skull base surgery. Endoscopic approaches were not taken into account when developing it, so it has not been validated for EES. Moreover, it does not specifically assess nasal morbidity, which is one of the key sources of morbidity after EES.[5–7,22] Therefore, in multiple studies, the impact of EES on HRQoL has been evaluated using the ASBQ, complemented by the SNOT-22 to evaluate nasal morbidity.[8,9,22–24] However, the SNOT-22 has not been validated in the setting of endoscopic skull base surgery.[14] In addition, the ASBQ was not designed for benign pathology, yet pituitary adenomas are among the most common types of benign tumors treated by neurosurgeons.[5,23] Malignant lesions are associated with worse HRQoL scores compared with benign lesions.[1,25–27] The ASK Nasal-12 is useful for assessing nasal morbidity after endonasal skull base surgery.[6] This instrument comprises items referring to the nose exclusively and it does not assess any other aspect of HRQoL. The Nasal Obstruction Symptom Evaluation Instrument (NOSE)[12] was developed for use in patients with chronic nasal obstruction. It is not applicable to patients undergoing septoplasty with concurrent endoscopic sinus surgery and, like the ASK Nasal-12[6], it is a unidimensional instrument. Both should be used with a generic QoL instrument to evaluate all aspects of HRQoL. De Almeida et al[13] developed the SBI to differentiate between HRQoL for different skull base tumors and their surgical treatment (endoscopic or open approaches). Although the SBI contains a few items that assess nasal morbidity, many more of its items are related to endocrine fluctuations after pituitary surgery, and it is the impact on nasal function that is of interest here.

Existing EES instruments are not fully aligned with the HRQoL concept. For this reason, we decided to develop a disease-specific, multidimensional, and comprehensive HRQoL instrument to evaluate nasal morbidity after EES. The EES-Q seems to be suitable for the evaluation of HRQoL in all patients undergoing endoscopic endonasal surgery, regardless of their diagnosis and the extent of their surgery. The complaints of EES patients may differ by their particular pathology (eg, chronic rhinosinusitis vs pituitary adenoma), so their scores on items and domains will be reflected in different overall scores. In the development and construction of a health outcome instrument, the content of the instrument should reflect the phenomena (eg, complaints) that may arise in a certain patient group (eg, patients undergoing EES). How these complaints are evoked (treatment A [eg, functional endoscopic sinus surgery] or treatment B [eg, extended EES]) is irrelevant, as long as the most important complaints are captured by an appropriate selection of the instrument's items.[21] An advantage of having a single multidimensional instrument is that it is no longer necessary to expect patients to fill out $\geq$2 questionnaires to evaluate HRQoL. This makes their task less time-consuming and requires less effort. Earlier studies showed that, for endoscopic skull base surgery, type of pathology (pituitary or nonpituitary tumor),[26] secreting vs nonsecreting tumors,[26] and presence of comorbidities[26] do not appear to be associated with postoperative ASBQ scores. Moreover, there is no conclusive evidence for the impact of nasoseptal flap reconstruction

How much were you bothered by the following complaints or in carrying out the following activities in the past two weeks

	Not al all	Mildly	Moderately	Severely	Very severely
1. Blocked nose	☐	☐	☐	☐	☐
2. Difficulty breathing through nose	☐	☐	☐	☐	☐
3. Dry mouth	☐	☐	☐	☐	☐
4. Need to blow nose	☐	☐	☐	☐	☐
5. Reduced sense of smell	☐	☐	☐	☐	☐
6. Reduced sense of taste	☐	☐	☐	☐	☐
7. Facial pressure	☐	☐	☐	☐	☐
8. Fitful sleep	☐	☐	☐	☐	☐
9. Tired	☐	☐	☐	☐	☐
10. Waking up tired	☐	☐	☐	☐	☐
11. Feeling depressed	☐	☐	☐	☐	☐
12. Sad	☐	☐	☐	☐	☐
13. Feeling down	☐	☐	☐	☐	☐
14. Distressed	☐	☐	☐	☐	☐
15. Aggravated	☐	☐	☐	☐	☐
16. Frustrated	☐	☐	☐	☐	☐
17. Stressed	☐	☐	☐	☐	☐
18. Tense	☐	☐	☐	☐	☐
19. Worried	☐	☐	☐	☐	☐
20. Discouraged	☐	☐	☐	☐	☐
21. Work / study	☐	☐	☐	☐	☐
22. Leisure time activities	☐	☐	☐	☐	☐
23. Hobbies	☐	☐	☐	☐	☐
24. Indoor activities at home	☐	☐	☐	☐	☐
25. Outdoor activities at home	☐	☐	☐	☐	☐
26. Going out for a visit	☐	☐	☐	☐	☐
27. Shopping	☐	☐	☐	☐	☐
28. Daily activities	☐	☐	☐	☐	☐
29. Engaging in outdoor activities	☐	☐	☐	☐	☐
30. Physical exertion	☐	☐	☐	☐	☐

FIGURE 2. The Endoscopic Endonasal Sinus and Skull Base Surgery Questionnaire (EES-Q). The final version of the EES-Q with 30 items is shown.

on HRQoL. Some recently published studies reported that nasoseptal flap reconstruction makes no significant contribution to nasal morbidity,[26,28] and other studies have described its negative impact on sinonasal symptoms and HRQoL.[26,29]

To select appropriate items in each domain, a literature review was performed and existing instruments in the field of interest were used. The factor analysis yielded a 3-factor solution, representing the 3 major HRQoL domains of physical, psychological and social well-being. The final EES-Q consisted of 30 items with high internal consistency for all domains. The item "nasal crusting" was eliminated from the instrument because our rotated factor solution showed no significant factor loading this item on one of the extracted factors. Our rationale seems to contradict that of De Almeida et al,[7] who found nasal crusting to be present on endoscopic examination in 98.0% of their patients. Both the frequency and severity of nasal morbidity after EES were quantified by Gallagher et al[30] using patient-reported outcome measures. In their study, nasal

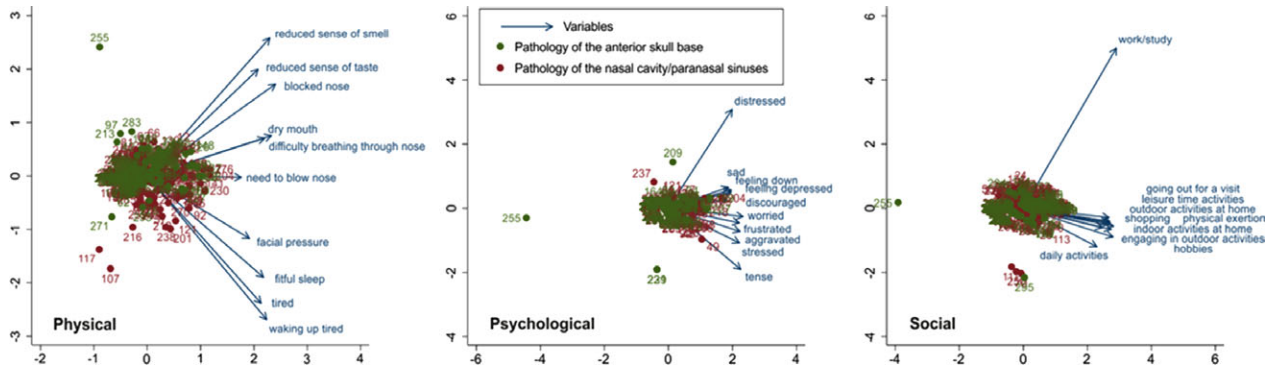

FIGURE 3. Biplots for each domain of the EES-Q. In the biplots, the marker symbols (dots) are displayed for patients, and arrows are displayed for the HRQoL items. Observations are projected to 2 dimensions such that the distance between the patients is approximately preserved. The cosine of the angle between arrows approximates the correlation between the items. The vectors represent the coefficients of the items in an HRQoL domain. The relative locations of the dots of patients with anterior skull base pathology (green) as well as patients with pathology of the paranasal sinuses (red) are very close together for the 3 domains of HRQoL. EES-Q = Endoscopic Endonasal Sinus and Skull Base Surgery Questionnaire; HRQoL = health-related quality of life.

crusting was reported by 43.0% of the patients, 45.0% of whom classified it as mild. An explanation for these discrepant findings could lie in the difference between symptomatic and nonsymptomatic crusting. It is likely that patients complain about nasal blockage caused by crusting, and that they do not complain about crusting itself. Thus, a surgeon's impression of a patient's well-being can be inaccurate.[31] Caregivers tend to overrate the influence of specific symptoms.[1] This tendency underscores the need for patient-reported assessment of HRQoL after EES.

The EES-Q was developed for use in a group of patients undergoing EES because of sinus or anterior skull base pathology, not for individual patients. The instrument can also be applied for individual patients, but the scores on the 3 domains would not be as reliable as on group level. A prospective study was conducted in a relatively large sample. A suitable method was used for item selection and appropriate statistical methods were used for item reduction. The fact that patients were recruited from a single university hospital center deserves attention because it could increase the potential for selection bias. We used a heterogeneous sample of patients, which is beneficial at the developmental stage. Cronbach's α depends on the variation in the population and will be higher in heterogeneous than in homogeneous populations. It is possible that the items in the psychological and social domain of the EES-Q are secondary to nasal morbidity and to an underlying condition. The aim of our study was not to predict or rule out "disturbing" factors as an underlying inflammatory condition. The EES-Q is an outcome instrument and its scores on the 3 health domains may find its origin from different sources. A strict causality between a specific medical treatment and other conditions cannot be precluded by the EES-Q itself. We do not believe that prior EES would bring bias to our study. Prior EES patients know what to expect and may have fewer complaints because they are used to these issues. However, selection of the items is largely based on factor analysis. This statistical technique used does not take into account the absolute score on the items, but only considers the correlation between items. In cases where patients are used to certain complaints, they may have lower scores on the items, but the linearity (correlation) between the items still holds.[21] In this study we have conducted an initial validity analysis in the process of corroborating the EES-Q. Our planned evaluation study, in which test-retest reliability and other validation steps are key elements, will provide methodological support for the concept underpinning the EES-Q. Strictly speaking, one does not validate a measurement instrument but rather some use to which the instrument is employed.[32] An instrument is neither valid nor invalid in and of itself but only in regard to how it is used and what interpretations are given to the measures for particular groups of people.

Conclusion

The EES-Q is a comprehensive, multidimensional, disease-specific instrument. It may provide valuable insight into issues relevant to patients undergoing EES due to sinus or skull base pathology. A distinguishing characteristic of this instrument is that, apart from the physical and psychological domains, it also encompasses a social domain. Understanding different aspects of HRQoL in patients undergoing EES may help caregivers restore, improve, or preserve patients' health through individualized care, which depends on identifying their specific needs. An evaluation of the psychometric properties of the EES-Q is forthcoming.

Acknowledgments

The authors thank the administrative staff at the Department Otorhinolaryngology–Head and Neck Surgery of the University Medical Center Groningen, Groningen, The Netherlands, for their efforts in distributing and collecting the questionnaires.

References

1. Kirkman MA, Borg A, Al-Mousa A, et al. Quality-of-life after anterior skull base surgery: a systematic review. *J Neurol Surg B Skull Base*. 2014;75:73–89.
2. Shah JP. Quality of life after skull base surgery: the patient's predicament. *Skull Base*. 2010;20:3–4.
3. Cella DF, Bonomi AE. Measuring quality of life: 1995 update. *Oncology (Williston Park)*. 1995;9:47–60.
4. Khanna D, Tsevat J. Health-related quality of life—an introduction. *Am J Manag Care*. 2007;13:218–223.
5. Bedrosian JC, McCoul ED, Raithatha R, et al. A prospective study of postoperative symptoms in sinonasal quality-of-life following endoscopic skull-base surgery: dissociations based on specific symptoms. *Int Forum Allergy Rhinol*. 2013;3:664–669.
6. Little AS, Kelly D, Milligan J, et al. Prospective validation of a patient-reported nasal quality-of-life tool for endonasal skull base surgery: the anterior skull base nasal inventory-12. *J Neurosurg*. 2013;119:1068–1074.
7. De Almeida JR, Snyderman CH, Gardner PA, et al. Nasal morbidity following endoscopic skull base surgery: a prospective cohort study. *Head Neck*. 2011;33:547–551.
8. McCoul ED, Anand VK, Bedrosian JC, et al. Endoscopic skull base surgery and its impact on sinonasal-related quality of life. *Int Forum Allergy Rhinol*. 2012;2:174–181.
9. Pant H, Bhatki AM, Snyderman CH, et al. Quality of life following endonasal skull base surgery. *Skull Base*. 2010;20:35–40.
10. De Almeida JR, Witterick IJ, Gullane PJ, et al. Quality of life instruments for skull base pathology: systematic review and methodologic appraisal. *Head Neck*. 2012;35:1221–1231.
11. Gil Z, Abergel A, Spektor S, et al. Development of a cancer-specific anterior skull base quality-of-life questionnaire. *J Neurosurg*. 2004;100:813–819.
12. Stewart MG, Witsell DL, Smith TL, et al. Development and validation of the nasal obstruction symptom evaluation (NOSE) scale. *Otolaryngol Head Neck Surg*. 2004;130:157-163.
13. De Almeida JR, Vescan AD, Gullane PJ, et al. Development of a disease-specific quality-of-life questionnaire for anterior and central skull base pathology—the skull base inventory. *Laryngoscope*. 2012;122:1933–1942.
14. Hopkins C, Gillett S, Slack R, et al. Psychometric validity of the 22-item sinonasal outcome test. *Clin Otolaryngol*. 2009;34:447–454.
15. Streiner DL, Norman GR. *Health Measurement Scales. A Practical Guide to Their Development and Use*. New York: Oxford University Press; 2008.
16. Radloff LS. The CES-D scale: a self-report depression scale for research in the general population. *Appl Psychol Measure*. 1977;1:385–401.
17. Beck AT, Steer RA, Garbin GM. Psychometric properties of the Beck Depression Inventory: twenty-five years of evaluation. *Clin Psychol Rev*. 1988;8:77–100.
18. Richardson J, Iezzi A, Khan MA, Maxwell A. Validity and reliability of the Assessment of Quality of Life (AQoL-8D) multi attribute utility instrument. *Patient Patient-Centered Outcomes Res*. 2014;7:85–96.
19. Gabriel KR. The biplot graphic display of matrices with application to principal component analysis. *Biometrika*. 1971;58:453–467.
20. ten Dam E, Korsten-Meijer AG, Schepers RH, et al. Calculating nasoseptal flap dimensions: a cadaveric study using cone beam computed tomography. *Eur Arch Otorhinolaryngol*. 2015;272:2371–2379.
21. Krabbe PFM. *The Measurement of Health and Health Status: Concept, Methods and Applications from a Multidisciplinary Perspective*. San Diego: Elsevier Academic Press; 2016.
22. McCoul ED, Anand VK, Schwartz TH. Improvements in site-specific quality of life 6 months after endoscopic anterior skull base surgery: a prospective study. *J Neurosurg*. 2012;117:498–506.
23. McCoul ED, Bedrosian JC, Akselrod O, et al. Preservation of multidimensional quality of life after endoscopic pituitary adenoma resection. *J Neurosurg*. 2015;123:813–20.
24. Kim BY, Son HL, Kang SG, et al. Postoperative nasal symptoms associated with an endoscopic endonasal transsphenoidal approach. *Eur Arch Otorhinolaryngol*. 2013;270:1355-1359.
25. Abergel A, Cavel O, Margalit N, et al. Comparison of quality of life after transnasal endoscopic vs open skull base tumor resection. *Arch Otolaryngol Head Neck Surg*. 2012;138:142–147.
26. Amit M, Abergel A, Fliss DM, et al. The clinical importance of quality-of-life scores in patients with skull base tumors: a meta-analysis and review of the literature. *Curr Oncol Rep*. 2012;14:175–181.
27. Gil Z, Abergel A, Spektor S, et al. Quality of life following surgery for anterior skull base tumors. *Arch Otolaryngol Head Neck Surg*. 2003;129:1303–1309.
28. Harvey RJ, Malek J, Winder M, et al. Sinonasal morbidity following tumour resection with and without nasoseptal flap reconstruction. *Rhinology*. 2015;53:122–128.
29. Alobid I, Ensenat J, Marino-Sanchez F, et al. Expanded endonasal approach using vascularized septal flap reconstruction for skull base tumors has a negative impact on sinonasal symptoms and quality of life. *Am J Rhinol Allergy*. 2013;27:426–431.
30. Gallagher MJ, Durnford AJ, Wahab SS, et al. Patient-reported nasal morbidity following endoscopic endonasal skull base surgery. *Br J Neurosurg*. 2014;28:622–625.
31. Gil Z, Abergel A, Spektor S, et al. Patient, caregiver, and surgeon perceptions of quality of life following anterior skull base surgery. *Arch Otolaryngol Head Neck Surg*. 2004;130:1276–1281.
32. Nunnally JC, Bernstein IH. *Psychometric Theory*. 3rd ed. New York: McGraw-Hill; 1994.